Substation Integration and Automation

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Intelligent Electronic Device (IED)

- Any device incorporating one or more processors with the capability to receive or send data/control from or to an external source (e.g., electronic multifunction meters, digital relays, controllers)
IED Interface Modules

- Eliminate Interface Modules by Putting Functionality in IED
  - Addressability
  - Protocol Conversion
  - Report-by-Exception
  - Data Filtering
  - Remote Configuration (Pass-Through)
  - Communication Physical Interface
  - Calculations and Time Stamping
Why Needed? Why Now?

- **DEREGULATION & COMPETITION**
  - Deregulation driving actions of most utilities
  - Major driving forces:
    - Improved power quality and service reliability
    - New energy related services and business areas
    - Lower cost of service
    - Information needed for improved decision making
  - SA: A proactive response to these forces
Why Needed? Why Now?

- DEVELOPMENT OF IEDs
  - Rapid development and deployment of Intelligent Electronic Devices (IEDs)
  - Protective relays
  - Meters
  - Equipment condition monitors
  - IEDs have become an integral part of Substation Automation systems
  - Technological developments have made SA Systems less expensive and more powerful
Why Needed? Why Now?

- **ENTERPRISE-WIDE INTEREST IN INFORMATION FROM IEDs**
  - “Operational” Data
    - Amps, volts, watts, VARs, fault location, switchgear status
  - “Non-Operational” Data
    - Equipment condition
    - Fault event and power quality data (waveforms)
  - Persons working outside the control room want access for improved decision making

![Diagram](image-url)

- **SA Platform**
- **EMS/DMS**
- **Corporate Data Warehouse**
Why Needed? Why Now?

- **IMPLEMENTATION AND ACCEPTANCE OF STANDARDS**
  - Confusion over industry communication standards is diminishing
  - International standards have become reality

UCA2 ↔ IEC61850

- Standards based implementation projects underway at many electric utilities
  - Widespread use of *de facto* standards for IED communications (DNP3, Modbus, Modbus+)
  - Some use of *de jure* standards (UCA2/IEC61850)
Leading obstacle to implementing Substation Automation is:

“Economic/Business Justification Case Not Made”

(Source: Report by Newton-Evans Research Company, 1997)
<table>
<thead>
<tr>
<th>Substation Integration and Automation Levels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Utility Enterprise</td>
</tr>
<tr>
<td>Substation Automation Applications</td>
</tr>
<tr>
<td>IED Integration</td>
</tr>
<tr>
<td>Intelligent Electronic Device (IED)</td>
</tr>
<tr>
<td>Implementation</td>
</tr>
<tr>
<td>Power System Equipment</td>
</tr>
<tr>
<td>(Transformers, Breakers)</td>
</tr>
</tbody>
</table>
Communication Paths From Substation:

- Two second data to SCADA system (operational data – extracted using industry standard protocol such as DNP3)
- On demand data to utility information server or data warehouse (non-operational data – extracted using IED vendor’s proprietary ASCII commands)
- Remote access from remote site to isolate a particular IED (also called “pass through” or “loop through”)
Communication Paths From Substation (continued)

<table>
<thead>
<tr>
<th>Utility Enterprise Connection</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCADA Data to MCC</td>
</tr>
<tr>
<td>Substation Automation Applications</td>
</tr>
<tr>
<td>IED Integration Via Data Concentrator/Substation Host Processor</td>
</tr>
<tr>
<td>IED Implementation</td>
</tr>
<tr>
<td>Power System Equipment (Transformers, Breakers)</td>
</tr>
</tbody>
</table>
Example of “Primary” Substation and “Secondary” Substation
Primary Substation Automation System
Operational and Non-Operational Data Paths

Enterprise Value Proposition

Operational Data

Data Warehouse

Substation Value Proposition

Corp WAN

TCP/IP

Engineering PC

Radio tower

Modem

Server

Data

Firewall

Router

Data Concentrator

Local HMI

Router

IED

IED

IED

IED

Workstation

Workstation

Workstation
Local vs. Enterprise Data Marts

- Local historian at substation level is a component of the Substation Automation System (e.g., PC with local substation HMI and historical data archiving) and is designed for Data Mart integration
  - Ability to push data From substation to enterprise Data Mart based on time, demand or event triggered
  - Enterprise Data Mart can pull data from local Data Mart in substation
The Virtual Enterprise Data Mart

- Integrates Data from Many Sources
- Manages Consistency and Owner of Record
- Supports Applications That Need to Reference Many Different Data Types
  - Alarm Files
  - Historical Loadings, Voltages, etc
  - Maintenance Records
  - Design Information
  - Fault Targets and IED ASCII Files
  - Waveform Data
  - GIS and Asset Data
  - Overhead Imagery and IR Imagery
Acquisition of Non-Operational Data Files – Basic Approach

Use manufacture specific software (or equivalent) to extract data from the IED (acSELerator, TapTalk, etc).

Capture the data acquired by this software in a non-proprietary format.

 Transmit (push or pull) the resultant data file to a shared drive on the corporate network.

Enable authorized personnel to access the data using standard analytical tools.
Approaches for Obtaining Non-Operational Data

- **Approach 1**: Download directly from the IED

- **Approach 2**: Use “Pass through” capabilities of substation data concentrator

- **Approach 3**: Local data concentrator as non-operational data server
Approach 1 - Direct Download Approach

Travel to the substation
Plug laptop containing manufacturer specific data into PC
Download data directly from the IED onto the laptop
Transfer the data to the corporate network via docking station or other data off load mechanism

Pro’s And Con’s
+ Low tech- low cost approach
- Not continuous monitoring – delays in retrieving data
Approach 2 - “Pass Through”

Copy of IED manufacturer specific software stored on IED access server
End user connects to access server using multi-level authentication
Access server establishes a “pass through” connection to IED in question via the substation data concentrator
End user interacts with the IED and downloads the required data as though desktop PC was directly connected to the PC in the substation
Downloaded data is then copied to a shared drive as necessary
Pro’s/Con’s:
+ Technically simpler than network approach
  - Promotes data silos
  - Requires special IED software on each desktop PC

Today, most systems use this approach!
Approach 3 - Data Concentrator as Non-Operational Data Gateway

- IED manufacturer software (acSELEnter, Tap talk, etc) or equivalent loaded onto substation data concentrator

- Data concentrator communicates directly with the IEDs to acquire non-operational data files

- Data concentrator converts data files to standard format

- Converted data file “pushed” or “pulled” into ELSI
Approach 3 - Data Concentrator as on-Operational Gateway

Advantage of this approach:
- Fewer field devices to manage from central location – 1 SDC versus multiple IEDs
- Data files transferred over WAN using FTP, OPC or other standard method versus IED specific protocol

Disadvantage
- SDC must support the IED proprietary ASCII protocols
  – Not many do at this time
Background

- State of the Industry...setting the table
  - 90%+ utilities implementing IEDs
  - Extracting only 15% of the benefits
  - Few Have ELSI Architecture and IT Infrastructure in Place
    - Substation, Communications, Data Mart
  - 85% remaining to be tapped – condition, performance, etc. – key indicators that drive the decisions that business users make everyday!
  - More and more utilities are starting to look at the problem
  - Enterprise data management today is where EMS was in 1975
    - Early Adoptors showing the way
Typical Current State and Implications

- Moderate penetration of IEDs and uneven adoption of existing enterprise data management standards
  - No Focused Plan for IED Penetration
- Continuous condition monitoring not being done today; nor is easy retrieval of equipment historical loadings, etc.
- Asset Management not supported by statistical data
- Fault Location not Automatically Integrated with Outage Management
- Lack of distance to fault information
- Many Maintenance / Operations procedures designed around EM relays and lack of continuous condition monitoring.
- Makes statistical analysis and project portfolio optimization difficult
All the Costs, None of the Benefits

- Current IED Deployment Rates Will NOT:
  - Improve reliability
  - Produce cost reductions
  - Increase operations efficiency
  - Allow process improvements

- But Current Rates Will:
  - Guarantee multiple technology families deployed across regions / districts
  - Data silos will persist
  - Prolong existence of EM relays
    - Which in turn prolongs existence of “RTU” equipment
## Opportunity Matrix - Examples

<table>
<thead>
<tr>
<th>Functions</th>
<th>Improve Reliability</th>
<th>Reduce Electrical Losses</th>
<th>Reduce Capital Expenditures</th>
<th>Reduce O&amp;M Costs</th>
<th>Increase Revenue</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Implementation</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corporate Data Repository</td>
<td>√</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Local User Interface and/or Elimination of Convertional displays / Controls</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reduce Panel Space/Wiring - Smaller Substation Size</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Integrated Protection</td>
<td>√</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Automation</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equipment Condition Monitoring</td>
<td>√</td>
<td></td>
<td></td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>Automated Load Restoration</td>
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<td></td>
<td></td>
<td>√</td>
<td>√</td>
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<tr>
<td>Feeder Automation Support</td>
<td>√</td>
<td></td>
<td></td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>Dynamic Equipment Rating</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disturbance Data Analysis</td>
<td>√</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adaptive Relaying</td>
<td>√</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Asset Management</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condition-Based Inspection &amp; Maintenance</td>
<td>√</td>
<td></td>
<td></td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>Improve Contingency Plans - Minimize Risk</td>
<td>√</td>
<td></td>
<td></td>
<td>√</td>
<td>√</td>
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<tr>
<td>Life Extension Plans</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condition-Based Replacement</td>
<td>√</td>
<td></td>
<td></td>
<td>√</td>
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<tr>
<td>&quot;Portfolio&quot; Management &amp; Optimization</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coordinated Asset Registry, Maintainence, Engineering &amp; Operations</td>
<td>√</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Best Practice Examples

- Comparable utilities are exploiting IEDs to achieve improved performance (reliability) at lower costs (Capital and O&M)
  - Fault location and dispatching
  - Condition Based Maintenance
  - Asset Management
  - Productivity improvements

- These utilities have a broad strategy for deploying and integrating IEDs and IT Systems to achieve business objectives
Project Benefits – Case Study

**Financial**
- Reduce reactive power flow
- Improve O&M efficiencies
- Reengineer work processes

**Reliability**
- Maintain power system control integrity
- Reduce Customer Average Interruption Duration Index (CAIDI) by 10 minutes on monitored circuits
- Improve maintenance to key power system components

**Environmental**
- Reduced reactive power = Reduced emissions
- Reduced emissions = Improved air quality
# Reported Benefits - Examples

<table>
<thead>
<tr>
<th>Description</th>
<th>First Cost $K</th>
<th>Annual Cost $000</th>
<th>Annual Benefit $000</th>
<th>Annual Benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>IEDs Integrated with OMS –</td>
<td>$1665</td>
<td>$285</td>
<td>$1800</td>
<td>7 minutes SAIDI</td>
</tr>
<tr>
<td>“</td>
<td>$3760</td>
<td>$610</td>
<td>$2320</td>
<td>3-5 minutes SAIDI</td>
</tr>
<tr>
<td>IED Driven CBI</td>
<td>$9500</td>
<td>$685</td>
<td>$1300</td>
<td></td>
</tr>
<tr>
<td>“</td>
<td>$2780</td>
<td>$380</td>
<td>$1150</td>
<td>5 yrs reported data</td>
</tr>
<tr>
<td>CBI Driven CBM</td>
<td>$3800</td>
<td>$1200</td>
<td>$2750</td>
<td>Incremental to CBI</td>
</tr>
<tr>
<td>Dynamic Equipment Ratings</td>
<td>$1400</td>
<td>$450</td>
<td>$850</td>
<td>Large US Pool Tie</td>
</tr>
<tr>
<td>“</td>
<td>$2900</td>
<td>$700</td>
<td>$1500</td>
<td>10 major lines</td>
</tr>
<tr>
<td>Intelligent Substation Alarming</td>
<td>$2780</td>
<td>$380</td>
<td>$1150</td>
<td>Targeted; smaller utility</td>
</tr>
<tr>
<td>Congestion Cost Reduction</td>
<td></td>
<td></td>
<td></td>
<td>No data yet but believed significant in some cases</td>
</tr>
</tbody>
</table>

*Italics = projected*
Enterprise Data Management Vision

COMMUNICATIONS

USER LEVELS

USER FUNCTIONS

DATA MART

SERVICE ORIENTED, BROWSER BASED INTERACTION FOR:
- RELAY TECHNICIANS
- FIELD STAFF
- ANALYSTS AND ENGINEERS
- PLANNERS
- DESIGNERS
- EXECUTIVES AND MANAGERS
- MARKETERS

MTCR

ENSURE NERC COMPLIANCE
ACCESS FROM MULTIPLE LOCATIONS
INTEGRATE SUBSTATION TO OFFICE TO CUST.

MULTIPLE LOGICAL NETWORKS INTO SUB
REDUCE IED DATA PASS THROUGH SCADA
FACILITATE FUTURE IED DEPLOYMENT
EXTEND BEYOND CURRENT IED DEPLOYMENT

drivers
benefits
consequences

EXTERNAL CUSTOMERS

ENTERPRISE USERS

IED USER BASE

SUBSTATION

TELEMETERED DATA

IED
IED
IED
IED

IED OPERATIONAL DATA
IED NON-OPERATIONAL DATA
METER DATA
SCADA DATA

OUTAGE DATA
ASSET MAINTENANCE DATA
WEATHER DATA

USER INTERACTION
ELSSI VIRTUAL DATA MART

USER INTERACTION
ELSSI DATA
Enterprise Data Management Overview

ELSSI Communications Vision

Operational Data Path
Non-Operational Path
Remote Access Path

Operational Path
Non-Operational Path
Remote Access Path

Frame Relay Strategy

Telemetric Environment

Operational Path
Non-Operational Path
Remote Access Path

Firewall
Data Concentrator
IED
Substation Environment

Feeder Environment
IED

Corporate WAN
Remote Access thru Corp. WAN (ex. VPN, RAS)

Server
Server
Data
Router
Firewall

56Kbps via internet web browser

Remote Access thru Corp. WAN (ex. VPN, RAS)

Laptop

KEMA
Overview…continued

- Substation [1]
  - IED Data Templates
  - Substation Integration Architecture
  - Substation Data Management (Operational and Non-Operational Data)
  - Substation Classes
  - Benefit Cost Analysis (BCA) for Substation Integration and Automation Candidate Functions
  - Start with Substation Data Requirements, then Reach Out to Feeders, Power Plants, etc.

- Communications Infrastructure [2]
  - Within Substation
  - Substation to Enterprise
  - Within Enterprise
Overview…continued

• Enterprise Data Management/Data Mart [3]
  – Data Requirements Matrix
  – Virtual Data Mart

• Business Processes [4]
  – Condition Based Inspection (CBI)
  – Condition Based Maintenance (CBM)
  – And Other Processes
  – Business Case Analysis for Business Processes

• Implementation [5]
  – Substation
  – Virtual Data Mart

• Applications [6]
IED Data Extraction - Standardization

- Determining which data to extract from each IED
  - Data Requirements Matrix (generated from interviews)
    - Requirements by user group (protective relay, predictive maintenance, planning, etc)
    - Consolidated requirements by circuit element (transformer, line, etc)
  - IED templates
    - Use results of Rata Requirements analysis to determine what data should be extracted from each IED
Sample Data Requirements Matrix
By User Group

<table>
<thead>
<tr>
<th>User Group</th>
<th>Circuit Component</th>
<th>Data Item</th>
<th>Type</th>
<th>Units</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protective Relay Engineering</td>
<td>Transmission lines, transformers, and busses</td>
<td>Fault oscillograph records; 3 ph voltages and currents,</td>
<td>Datafile</td>
<td></td>
<td>Wavewin</td>
</tr>
<tr>
<td>Protective Relay Engineering</td>
<td>Transmission lines, transformers, and busses</td>
<td>Sequence of events reports: breaker contacts, relay targets, etc.</td>
<td>Datafile</td>
<td></td>
<td>Wavewin</td>
</tr>
<tr>
<td>Protective Relay Engineering</td>
<td>Transmission, subtransmission, or distribution circuit</td>
<td>Line current A,B,C phase</td>
<td>AI</td>
<td>Amperes</td>
<td>EMS</td>
</tr>
<tr>
<td>Protective Relay Engineering</td>
<td>Transmission, subtransmission, or distribution circuit</td>
<td>Line-to-neutral voltages AN, BN, CN</td>
<td>AI</td>
<td>Kilovolts</td>
<td>EMS</td>
</tr>
<tr>
<td>Protective Relay Engineering</td>
<td>Circuit Breaker</td>
<td>Open/closed status</td>
<td>DI</td>
<td></td>
<td>EMS</td>
</tr>
<tr>
<td>Protective Relay Engineering</td>
<td>Protective Relays</td>
<td>Active settings group</td>
<td>AI</td>
<td>N/A</td>
<td>Protective relay IED via dialup</td>
</tr>
<tr>
<td>Predictive Maintenance</td>
<td>Load Tap Changer</td>
<td>Voltage (source and load side)</td>
<td>AI</td>
<td>Kilovolts</td>
<td>EMS</td>
</tr>
<tr>
<td>Predictive Maintenance</td>
<td>Voltage Regulator</td>
<td>Raise/lower tap draghands</td>
<td>AI</td>
<td>Taps</td>
<td>Obtained manually</td>
</tr>
<tr>
<td>Predictive Maintenance</td>
<td>Substation Transformer</td>
<td>Dissolved gases: H2 content</td>
<td>AI</td>
<td>Percent</td>
<td>MMS</td>
</tr>
<tr>
<td>Predictive Maintenance</td>
<td>Substation Transformer</td>
<td>Dissolved gases: Carbon monoxide content</td>
<td>AI</td>
<td>Percent</td>
<td>MMS</td>
</tr>
<tr>
<td>Predictive Maintenance</td>
<td>Substation Transformer</td>
<td>Dissolved gases: Acetylene content</td>
<td>AI</td>
<td>Percent</td>
<td>MMS</td>
</tr>
</tbody>
</table>
Sample Data Requirements Matrix
By Circuit Component

<table>
<thead>
<tr>
<th>Circuit Component</th>
<th>Data Item</th>
<th>Format</th>
<th>Units</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Circuit Breaker</td>
<td>Average close electrical operating time</td>
<td>AI</td>
<td>milliseconds</td>
<td>SL 2032</td>
</tr>
<tr>
<td>Circuit Breaker</td>
<td>Average close mechanical operating time</td>
<td>AI</td>
<td>milliseconds</td>
<td>SL 2032</td>
</tr>
<tr>
<td>Circuit Breaker</td>
<td>Average trip electrical operating time</td>
<td>AI</td>
<td>milliseconds</td>
<td>SL 2032</td>
</tr>
<tr>
<td>Circuit Breaker</td>
<td>Average trip mechanical operating time</td>
<td>AI</td>
<td>milliseconds</td>
<td>SL 2032</td>
</tr>
<tr>
<td>Circuit Breaker</td>
<td>Breaker wear percentage trip contact A,B,C</td>
<td>AI</td>
<td>%</td>
<td>SL 2032</td>
</tr>
<tr>
<td>Circuit Breaker</td>
<td>Close contact A,B,C total current</td>
<td>AI</td>
<td>dc amps</td>
<td>SL 2032</td>
</tr>
<tr>
<td>Circuit Breaker</td>
<td>Close contact A,B,C total energy</td>
<td>AI</td>
<td>megajoules</td>
<td>SL 2032</td>
</tr>
<tr>
<td>Circuit Breaker</td>
<td>Last electrical close operating time A,B,C</td>
<td>AI</td>
<td>milliseconds</td>
<td>SL 2032</td>
</tr>
</tbody>
</table>
# Sample IED Template

## SEL-352 Relay Data Template

<table>
<thead>
<tr>
<th>DNP Object Type</th>
<th>Index</th>
<th>Description</th>
<th>Circuit Breaker</th>
</tr>
</thead>
<tbody>
<tr>
<td>20,22</td>
<td>00</td>
<td>Active settings group.</td>
<td></td>
</tr>
<tr>
<td>20,22</td>
<td>01</td>
<td>Breaker Trip A.</td>
<td>X</td>
</tr>
<tr>
<td>20,22</td>
<td>02</td>
<td>Breaker Trip B.</td>
<td>X</td>
</tr>
<tr>
<td>20,22</td>
<td>03</td>
<td>Breaker Trip C.</td>
<td>X</td>
</tr>
<tr>
<td>20,22</td>
<td>04</td>
<td>Breaker Close A.</td>
<td>X</td>
</tr>
<tr>
<td>20,22</td>
<td>05</td>
<td>Breaker Close B.</td>
<td>X</td>
</tr>
<tr>
<td>20,22</td>
<td>06</td>
<td>Breaker Close C.</td>
<td>X</td>
</tr>
<tr>
<td>20,22</td>
<td>07</td>
<td>Failed CB Trip Resistors Put in Service.</td>
<td></td>
</tr>
<tr>
<td>20,22</td>
<td>08</td>
<td>Failed CB Close Resistors Put in Service.</td>
<td></td>
</tr>
<tr>
<td>20,22</td>
<td>09</td>
<td>52A contradicts voltage.</td>
<td></td>
</tr>
<tr>
<td>30,32</td>
<td>23</td>
<td>Avg. Electrical Time (ms) TRIP A</td>
<td>X</td>
</tr>
<tr>
<td>30,32</td>
<td>24</td>
<td>Avg. Electrical Time (ms) TRIP B</td>
<td>X</td>
</tr>
<tr>
<td>30,32</td>
<td>25</td>
<td>Avg. Electrical Time (ms) TRIP C</td>
<td>X</td>
</tr>
<tr>
<td>30,32</td>
<td>26</td>
<td>Avg. Electrical Time (ms) CLOSE A</td>
<td>X</td>
</tr>
<tr>
<td>30,32</td>
<td>27</td>
<td>Avg. Electrical Time (ms) CLOSE B</td>
<td>X</td>
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<tr>
<td>30,32</td>
<td>28</td>
<td>Avg. Electrical Time (ms) CLOSE C</td>
<td>X</td>
</tr>
<tr>
<td>30,32</td>
<td>29</td>
<td>Avg. Mechanical Time (ms) TRIP A</td>
<td>X</td>
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<tr>
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<td>Avg. Mechanical Time (ms) TRIP B</td>
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<tr>
<td>30,32</td>
<td>31</td>
<td>Avg. Mechanical Time (ms) TRIP C</td>
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<td>30,32</td>
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<td>Avg. Mechanical Time (ms) CLOSE A</td>
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<tr>
<td>30,32</td>
<td>33</td>
<td>Avg. Mechanical Time (ms) CLOSE B</td>
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<tr>
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<td>34</td>
<td>Avg. Mechanical Time (ms) CLOSE C</td>
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<td>Last Electrical Time (ms.) TRIP A</td>
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<tr>
<td>30,32</td>
<td>36</td>
<td>Last Electrical Time (ms.) TRIP B</td>
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Develop Design Characteristics for Standard Sub Auto Configuration

- Handling of three data paths:
  - Operational data
  - Non-operational data
  - Remote access (administrative data)
- IED interfaces and protocols (op, non-op, and admin data)
- Local user interface
- Cyber security
- Local data processing capabilities (per-processing and sequence control logic)
- Handling of hardwired data items
- Time synchronization
Representative SA Architecture

- Remote Access
  - Telephone
  - "Pass Through"

- Firewall/Router
  - Serial DNP3
  - FTP TCP/IP
  - Modem

- Substation Data Concentrator (Master)

- Substation Data Concentrator (Slave)
  - DNP3, Modbus
  - GPS Receiver

- IED
  - Hardwired I/O

- Local HMI

- SCADA EMS
- Enteprise Data Warehouse

- PLC for Sequence Control Logic
Thank You!